Insights on 3D evolution of CMEs in the inner corona

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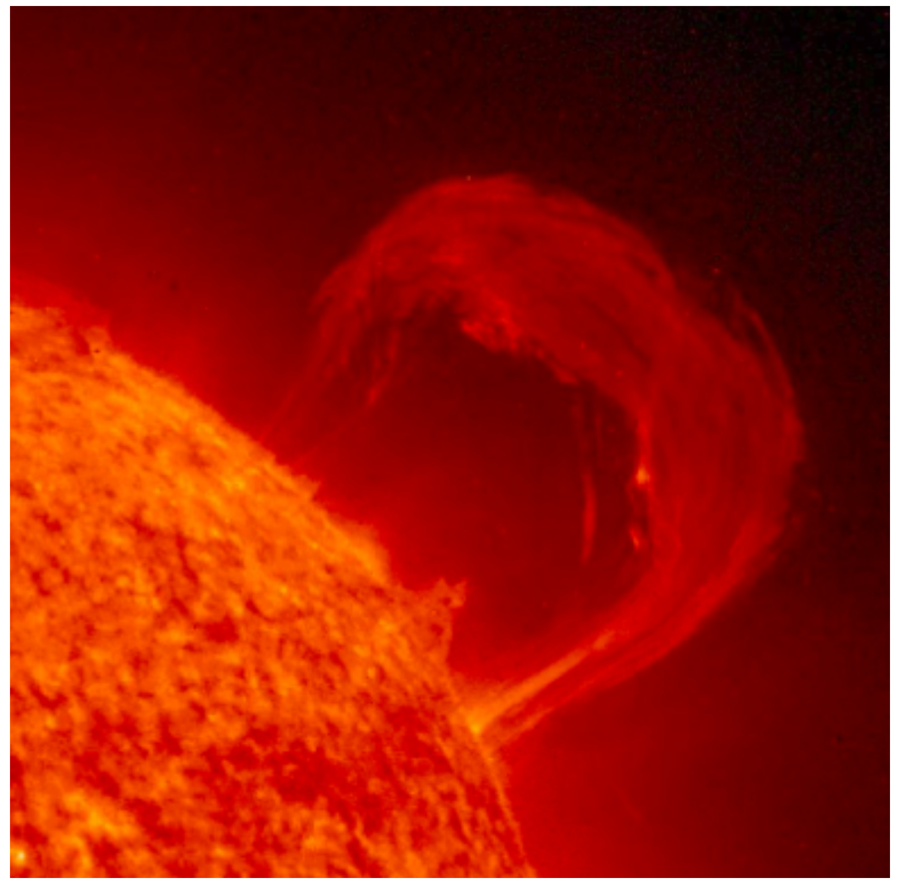
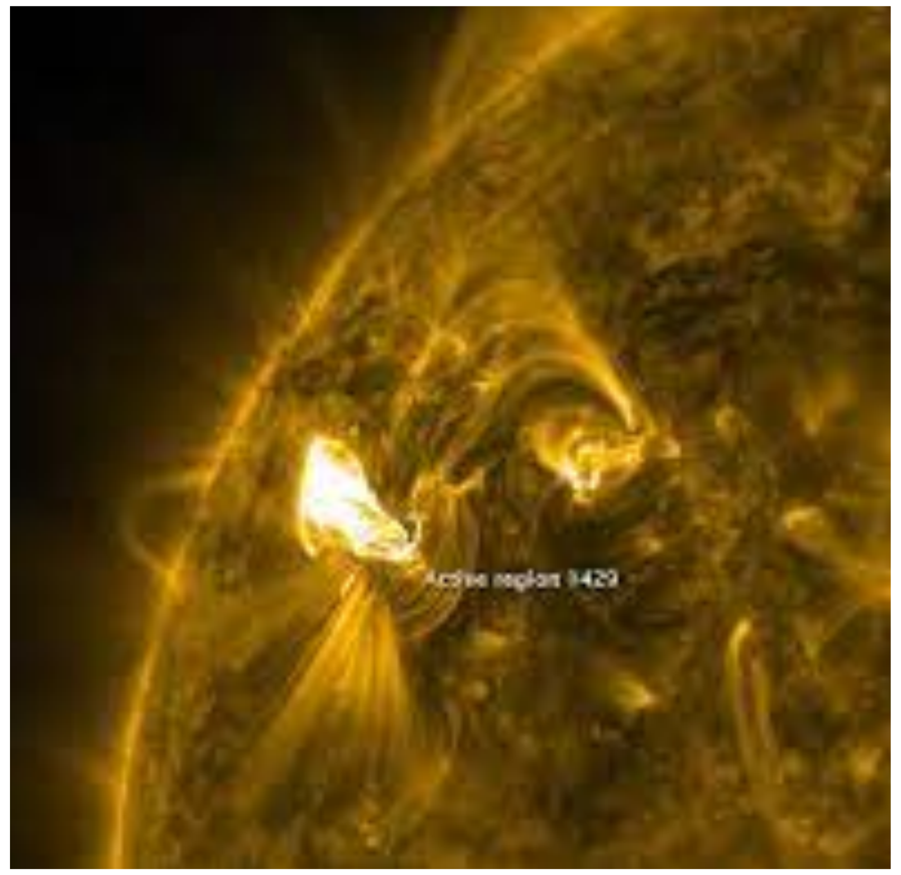
Overview : 3D kinematics of 59 CMEs are studied in the STEREO COR - 1 and COR - 2 field of view with the help of the Graduated Cylindrical Shell (GCS) model (Thernesien et al. 2009). The fitted model parameters are then analysed for a better understanding of the initial kinematics of CMEs in the inner (< 3R) and outer corona.



Quiescent prominences (PEs)



Active Regions (ARs)

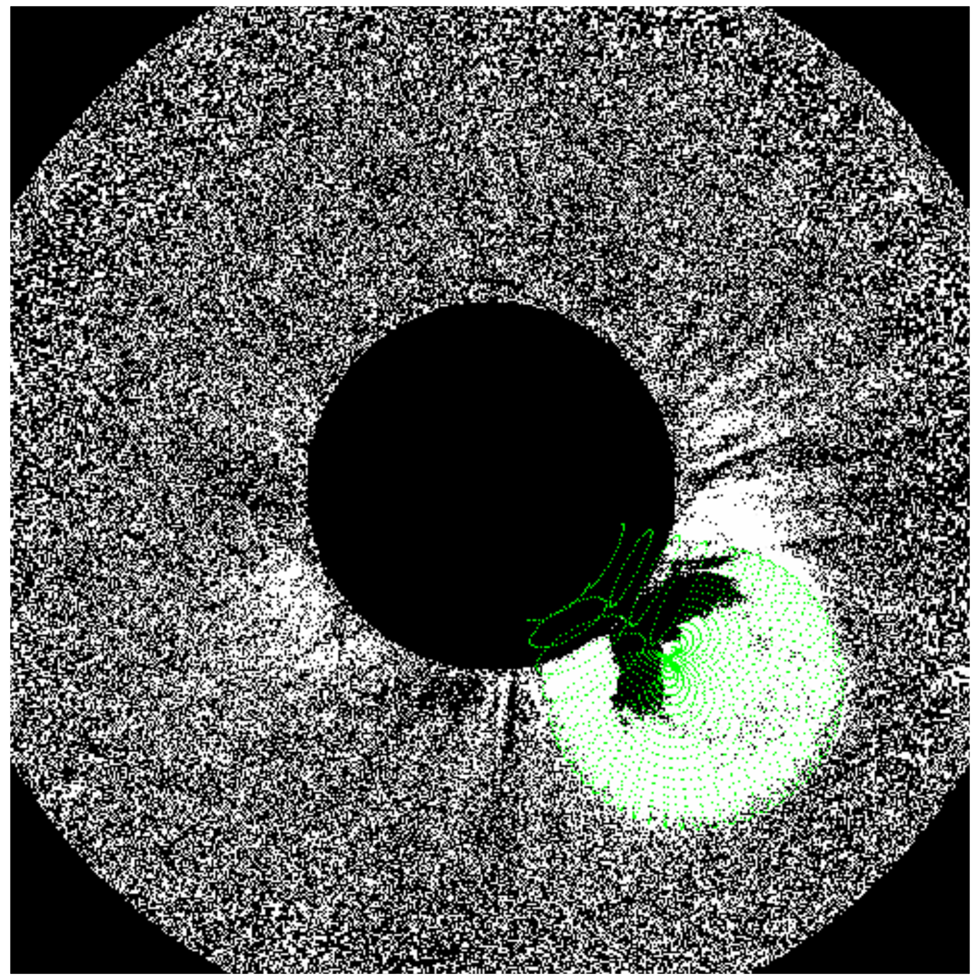
The source regions of all 59 CMEs were identified using back projection. The identified sources were classified into 3 classes :

ARs - 20/59

PEs - 20/59

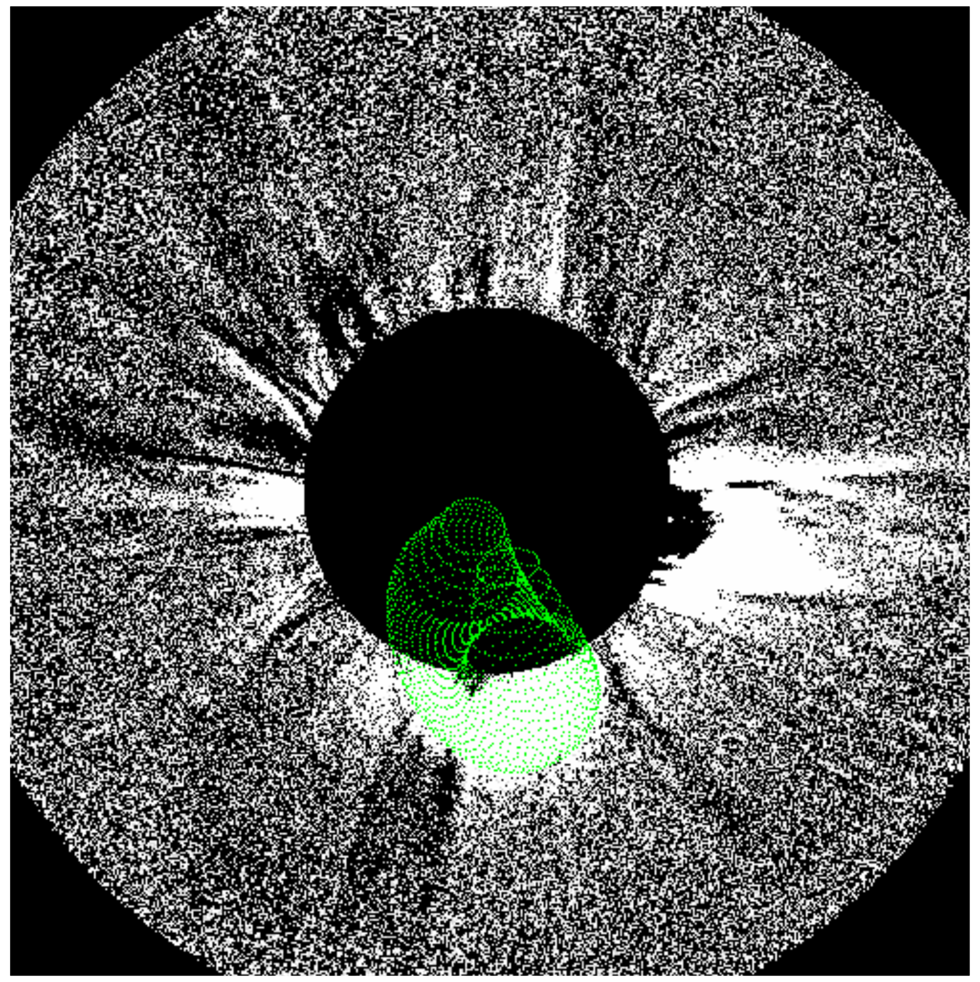
APs - 19/59

Active Prominences (APs) : PEs with foot-point(s) connected to ARs



STEREO - A / COR - 1

The pair of COR - 1 images are fitted with the synthetic flux-rope generated from the GCS model to capture the evolution in inner corona, and so is done for COR - 2 images as well.

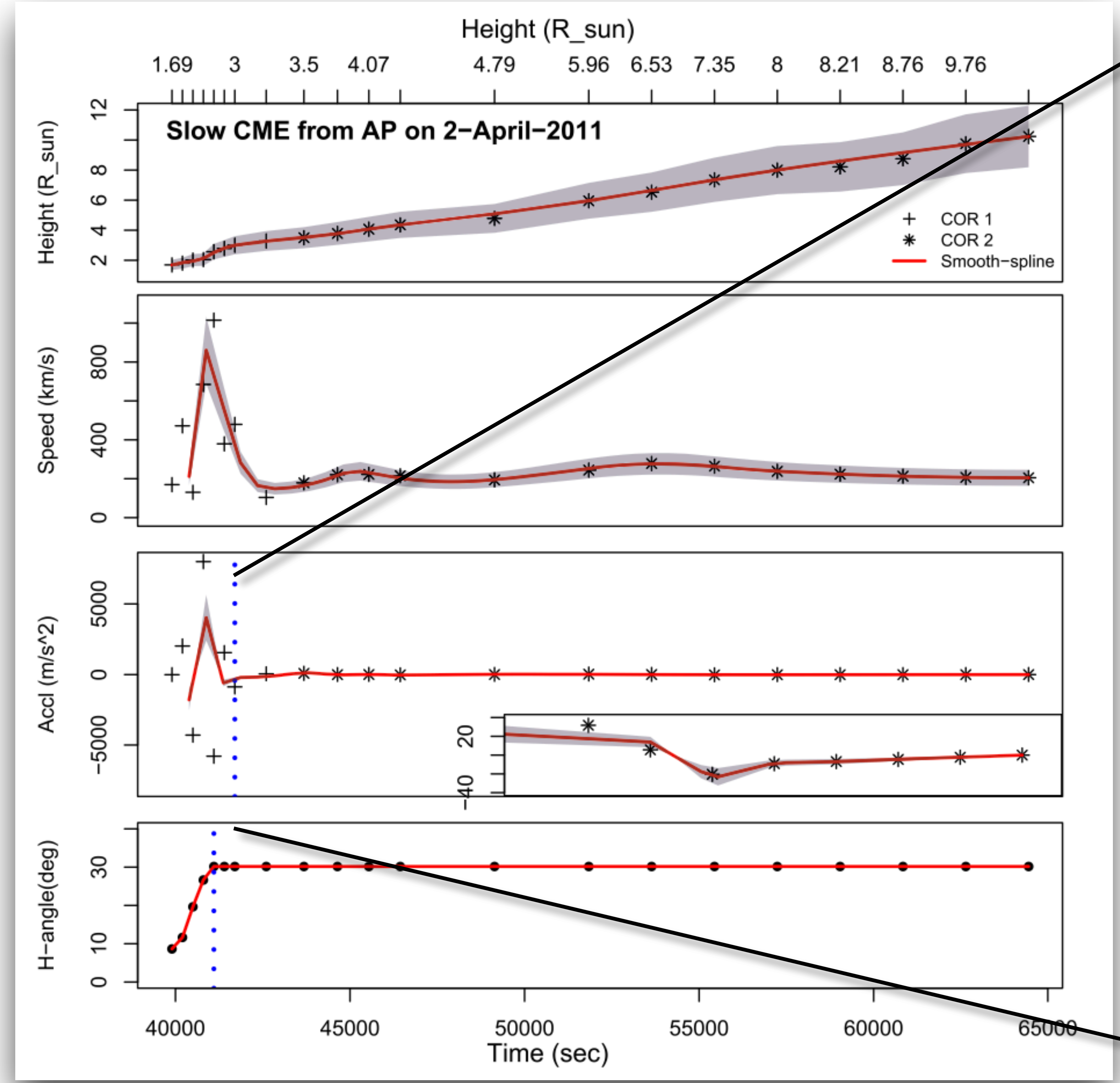


STEREO - B / COR - 1

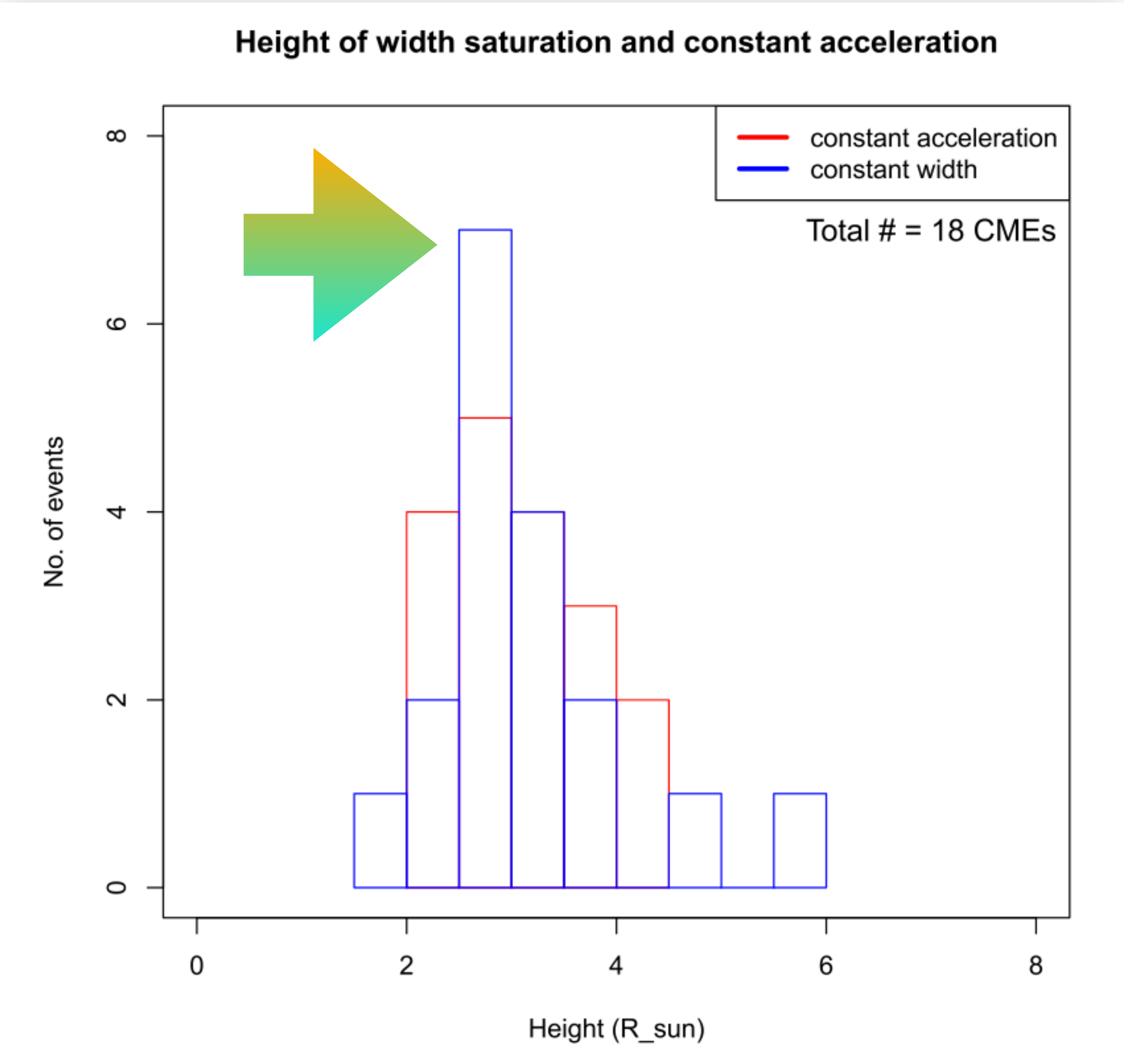
Table 1
GCS Model Parameters of All the CMEs

Date	Time (hh:mm:ss)	Source Region	Height (h) ($R_\odot$)	Longitude (ϕ) (deg)	Latitude (θ) (deg)	Tilt angle (γ) (deg)	Aspect ratio (k)	Half-angle (α) (deg)	V_{CDAW} (km s^{-1})	V_{GCS} (km s^{-1})
2007 May 9	02:00:00	AR	3.36	69	3.9	–	0.33	0	264	277
2008 Mar 25	19:20:00	AR	3.36	188	−15	69	0.17	12	1103	1074
2008 Mar 26	10:52:22	AR	3.71	1	−5	2	0.21	4	163	241
2008 Apr 5	16:15:00	PE	3.35	258	0	−65	0.13	14	962	994
2008 Apr 9	10:45:00	AP	3.22	193	−21	2	0.12	8	650	543

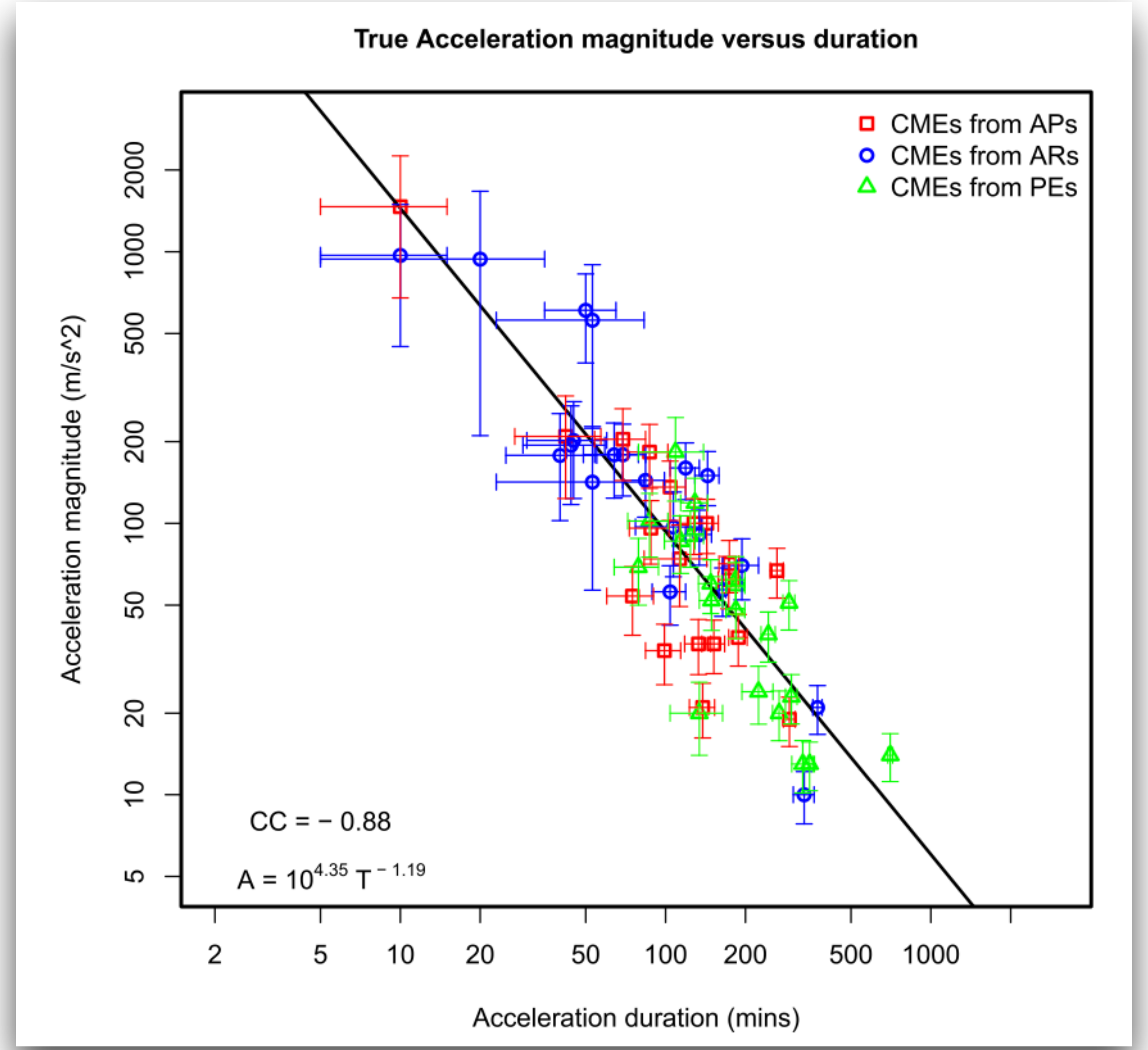
Radial and lateral evolution of CMEs in inner corona : Observational evidence of Lorentz force imprints



The h-t, v-t, a-t and width-time profiles of an impulsive CME. The dotted lines in 3rd and 4th panel marks the height at which impulsive acceleration phase and rapid width expansion phase ceases !!



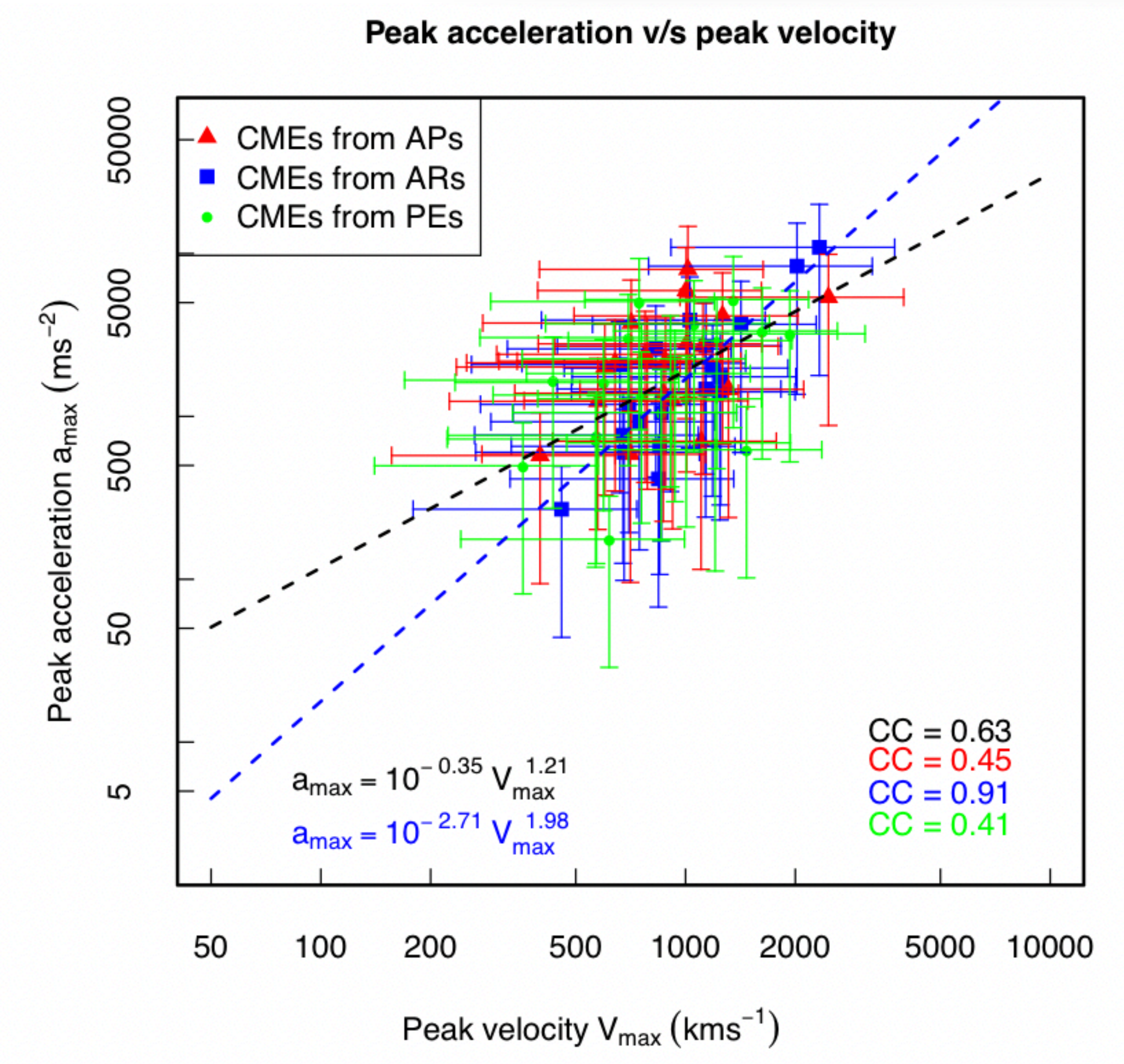
Statistically, both the distributions for most CMEs peak around 2.5-3 R. Thus showing the influence of Lorentz force on 3D kinematics stays dominant till 2.5-3R.

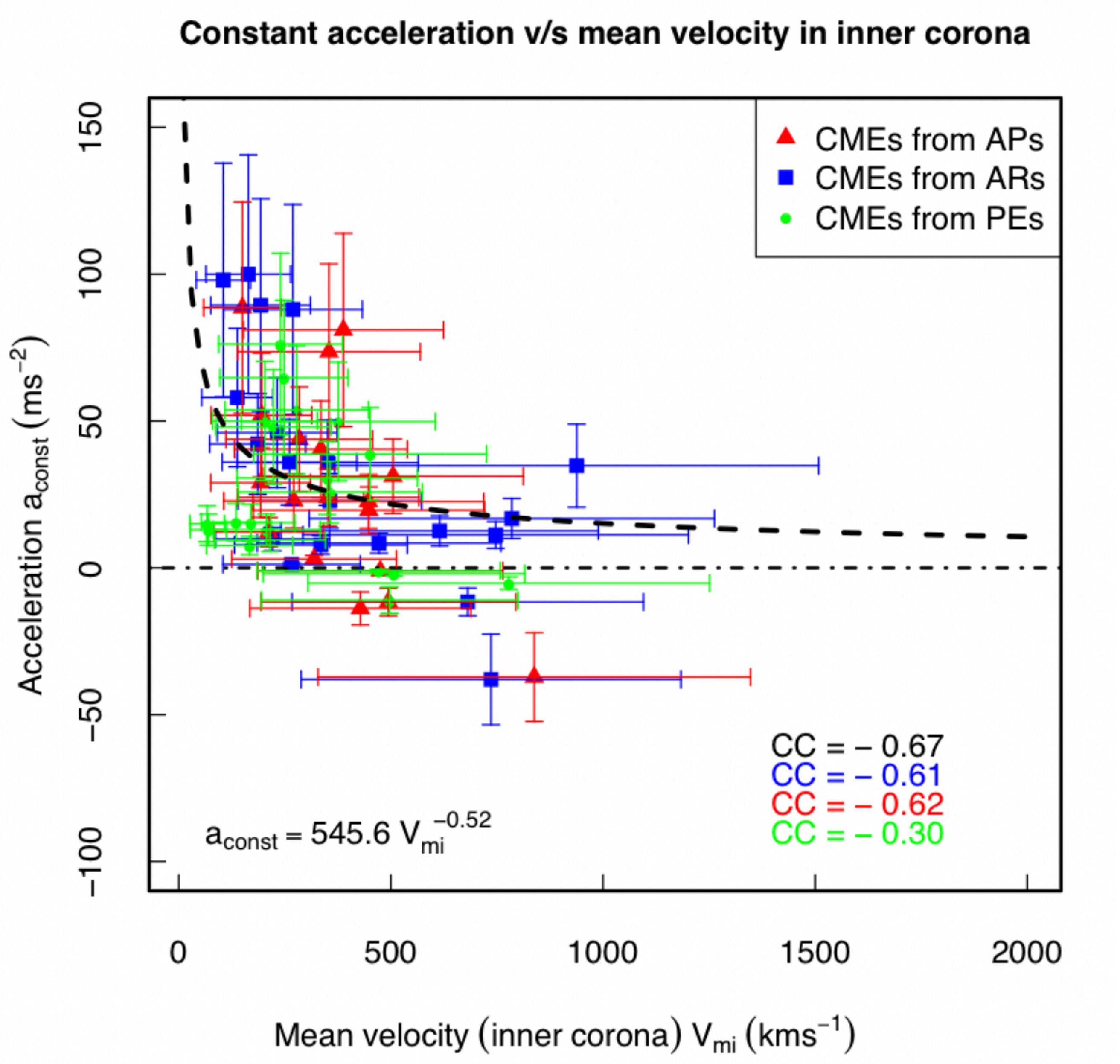


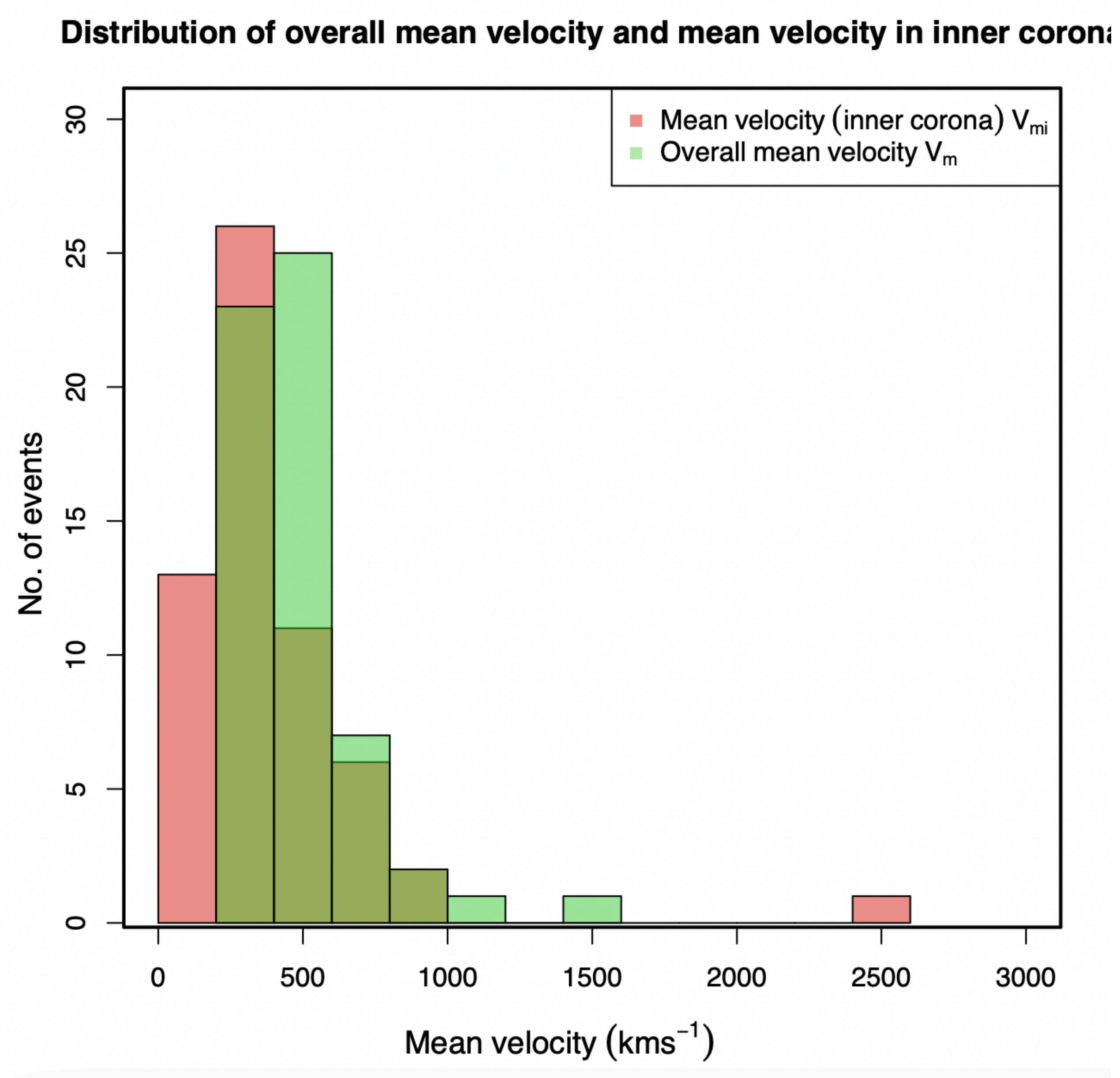
We find the same anti-correlation holds for CMEs from different source regions (ARs,PEs and APs). This also shows the marked difference between CMEs connected to PEs tending to be mostly gradual events, while those connected to ARs are impulsive.

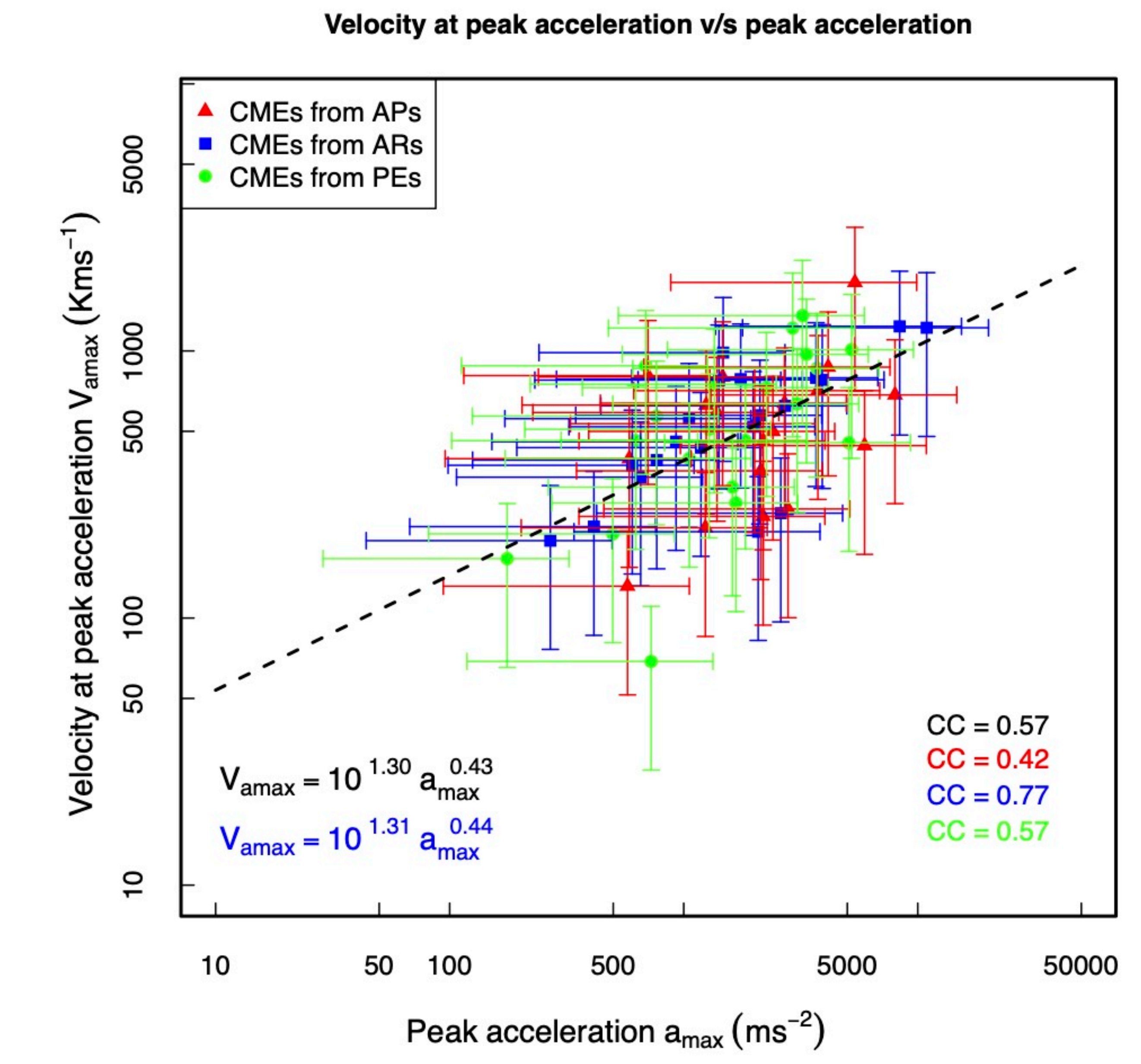
We connected the true width expansion and radial acceleration profiles in 3D and found that they are veritable manifestation of the same Lorentz force. Further, from from the width-acceleration unification, we reported on the height range till which the impact of Lorentz force stays dominant in the innr coronal kinematics of CMEs !!

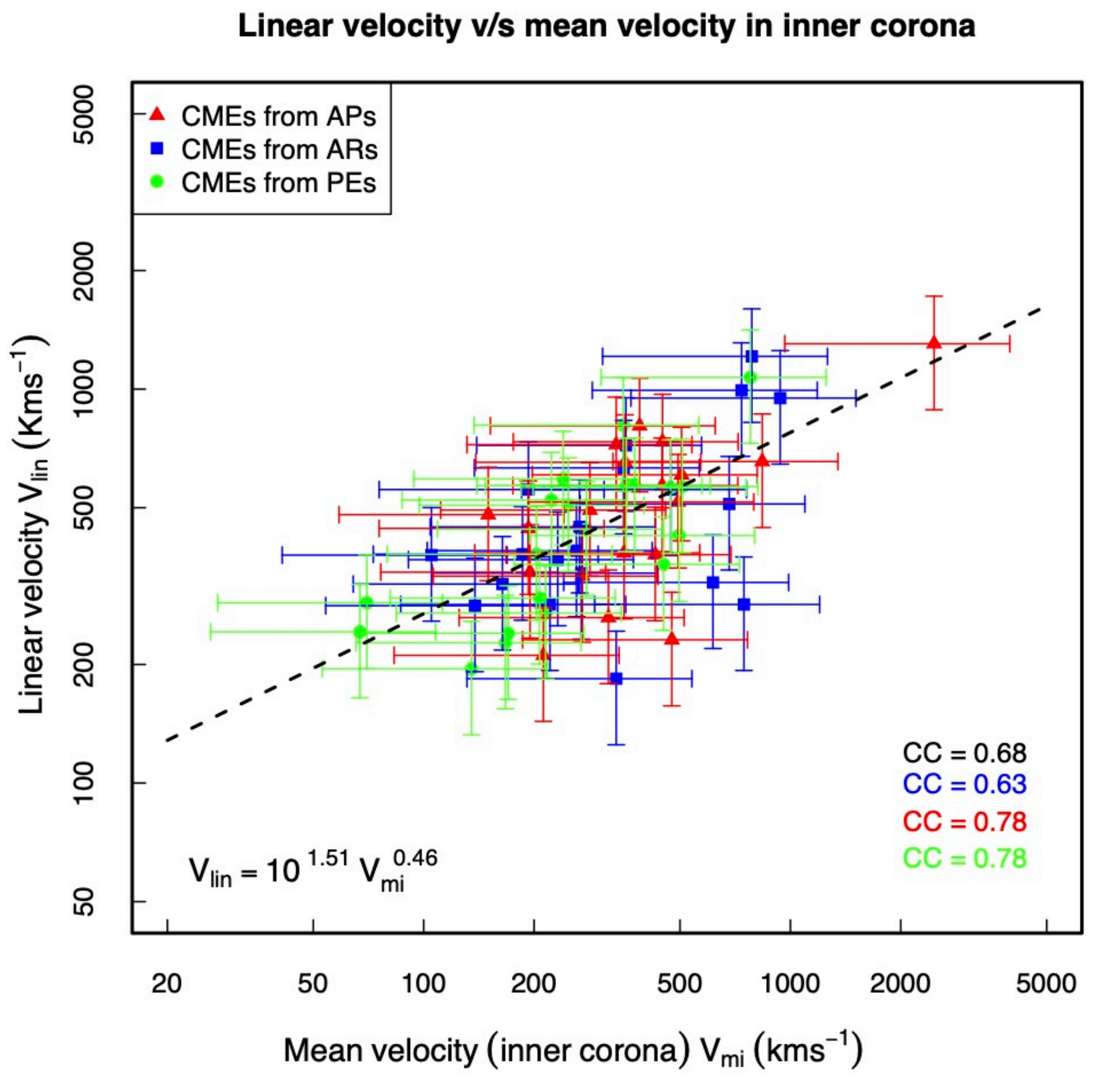
Coupling of kinematics in the inner and outer corona, source region imprints..

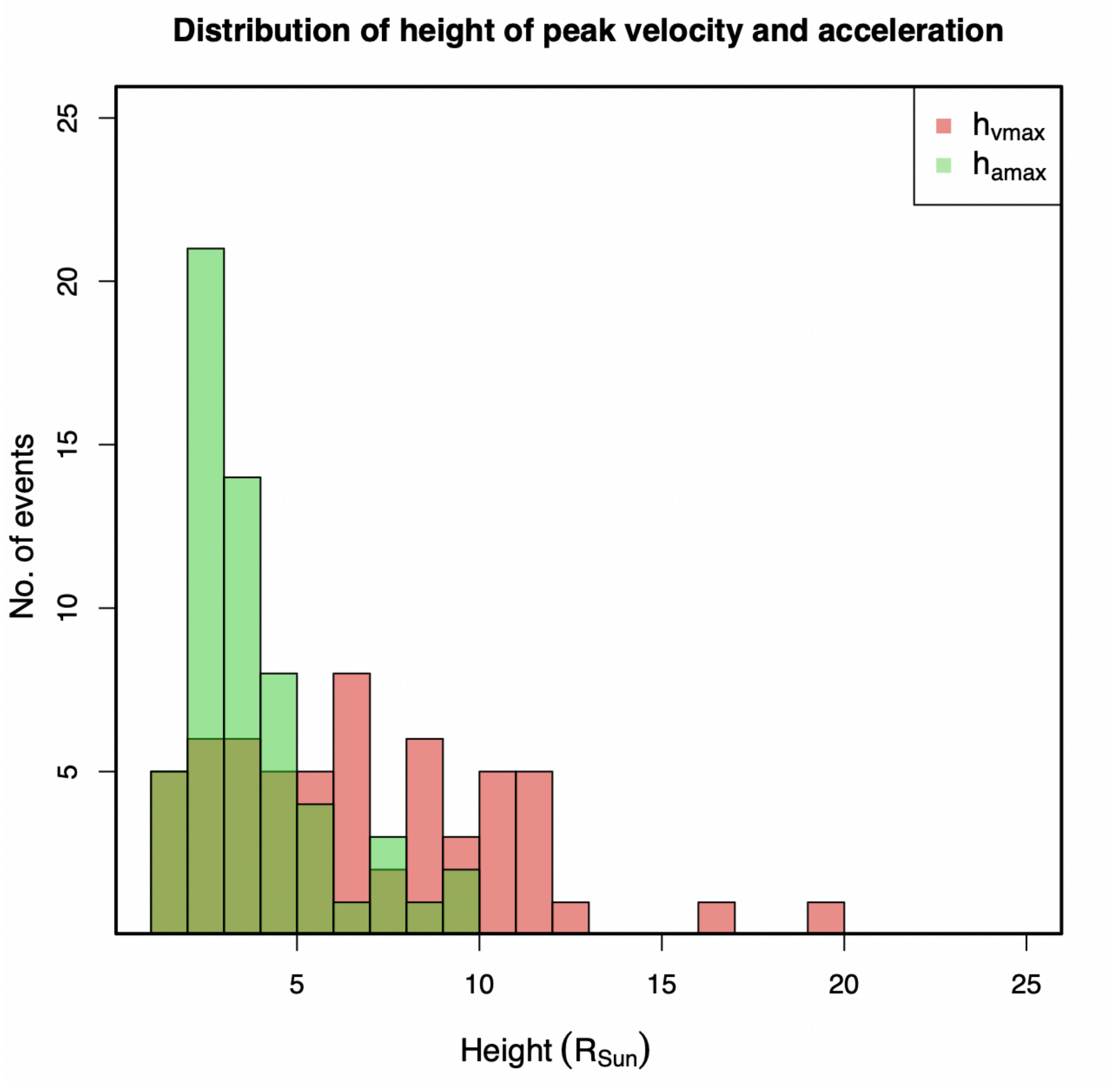












Our Take Home Points :

- Peak speeds and accelerations are better correlated for CMEs connected to ARs
- The drag influence of solar wind can even start as early as in the inner corona itself. Also, the a-v anti-correlation is much weaker for CMEs from PEs, is the drag interaction different ??
- Inner coronal Observations can be used for CME arrival time estimation with minimised lead time of prediction !!
- The average speeds are different in the inner and outer corona. A look back into tagging CMEs with a single average speed
- The height of peak aacelerations lies in the range 2.5-3R, thus indicating that it is Lorentz force that propels the CMEs to peak accelerations !!

References :

- **Majumdar, S., Pant, V., Patel, R., & Banerjee, D. 2020, ApJ, 899, 6**
- **Majumdar, S., Patel, R., Pant, V., Banerjee, D., 2021, ApJ**

Thank You..